First Physics Results from the Sudbury Neutrino Observatory

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The Sudbury Neutrino Observatory (SNO) is a 1000 T imaging Heavy Water (D_2O) Cerenkov detector[1] located near Sudbury Ontario Canada. The detector is located 2090 meters underground in INCO's Creighton Mine. SNO was designed to address the solar neutrino problem (SNP). The SNP is the result of over 30 years of experimentation that have measured fewer neutrinos than are predicted by solar models. One explanation for the deficit is the transformation of electron-type neutrinos into other neutrino flavors.

SNO detects ^{8}B solar neutrinos through the reactions:

$\nu_e + d \Rightarrow p + p + e^-$ (CC)

$\nu_x + d \Rightarrow p + n + \nu_x$ (NC)

$\nu_e + e^- \Rightarrow \nu_e + e^-$ (ES)

The charged current (CC) reaction is sensitive exclusively to electron-type neutrinos, while the neutral current (NC) is sensitive to all active neutrino flavors (x= e, μ, τ). The elastic scattering (ES) reaction is sensitive to all flavors, but with reduced sensitivity to ν_μ and ν_τ. The comparison of the ^{8}B neutrino flux deduced from the ES reaction ($\phi^{ES}(\nu_x)$) to the flux measured by the CC reaction ($\phi^{CC}(\nu_e)$) can provide a direct test of flavor transformation independent of solar models. If the ^{8}B solar neutrinos change into other active flavors then $\phi^{ES}(\nu_x) > \phi^{CC}(\nu_e)$.

In its first phase of operation, SNO collected data from a pure D_2O target. In this mode the detector was primarily sensitive to CC and ES reactions. NC reactions were recorded with a reduced efficiency for neutrons detection (compared to either NaCl or NCD phases). SNO reported results from 240.95 live-days of operation[2]. Using a fiducial volume cut of $R_{event} <$ 550 cm (from the 600cm radius of D_2O target) and a kinetic energy cut $T_{eff} \geq 6.75$ MeV SNO reported 975.4 ± 39.7 CC events, 106,1 ±15.2 ES events, and 87.5 ± 24.7 neutron events. These correspond to fluxes (in units of $10^6/cm^2/s$) of:

$$\phi^{CC}_{SNO}(\nu_e) = 1.75 \pm 0.07(\text{stat})^{+0.12}_{-0.11}(syst) \pm 0.05(theor)$$

$$\phi^{ES}_{SNO}(\nu_x) = 2.39 \pm 0.34(\text{stat})^{+0.16}_{-0.14}(syst)$$

The difference between the Super-K's high precision measurement of ^{8}B ES reaction flux[3] and SNO's CC flux is 0.57±0.17 x0 $10^6/cm^2/s$ or a 3.3σ effect. For reference SNO's $\phi^{CC}(\nu_e)$ is 0.347±0.029 of the BPB2001 solar model[4].

From this we infer $\phi(\nu_{\mu,\tau})=3.69\pm1.13\times10^6/cm^2/s$ and $\phi(\nu_x)=5.44\pm0.99\ \times10^6/cm^2/s$

In summary SNO presented the first direct indication of a nonelectron flavor component in the solar neutrino flux and enabled the first determination of the total flux of ^{8}B solar neutrinos.

Footnotes and References

1. The SNO Collaboration, J. Boger *et al* NIM A449, 172 (2000).
2. The SNO Collaboration, Q.R. Ahmad, *et al* PRL **87** 071301.
3. S. Fukuda, *et al.* PRL **86**, 5651 (2001).
4. J.N. Bahcall, M.H. Pinsonneault, and S. Basu, Astrophys. J. **555**, 990 (2001).

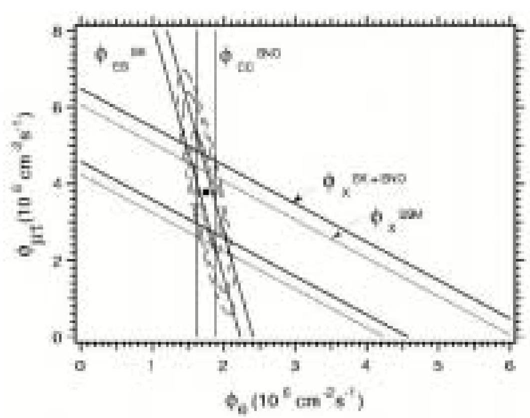

Fig. 1. Flux of ^{8}B solar neutrinos which are μ or τ flavor vs the flux of electron neutrinos as deduced from the SNO and Super-K data.